# *Health Risks and Costs That May Be Attributable to Electric and Magnetic Field Exposures in California Public Schools*

FINAL REPORT
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# Introduction

This report provides data that can be used to estimate the social costs of deaths and diseases potentially attributable to exposures to power frequency electric and magnetic fields (EMFs). The data were compiled for use with quantitative decision analysis models developed for issues surrounding EMF exposures in public schools and day care centers as a part of the California Electric and Magnetic Fields Program. Data on disease incidence and specific causes of death were obtained directly from California and USA records. Estimates of the costs of death and disease were derived from existing compilations prepared by others and not from original analysis. Although efforts were made to acquire accurate current information, detailed up-to-date costs for each of the many diseases potentially associated with EMF exposure are not essential for the purposes of decision analysis modeling and policy development. Instead, the utility of this report rests in the provision of data sufficient for estimating the range of benefits that might result from alternative EMF policies. Given the large scientific uncertainties surrounding the causation of disease by EMF exposure, uncertainties surrounding the monetary benefits of averting disease are relatively small.

Several types of information are needed for an economic analysis of health costs. Although some information may be specific to a particular agent, the methods underlying health cost economics can be applied to health factors as diverse as tobacco smoking, asbestos, accidental injury, infectious diseases, and EMFs. For example, an agent like asbestos has a strong relationship to a particular form of lung cancer, but tobacco smoking is related to a variety of diseases, of which the most prominent are lung cancer, emphysema, and heart disease. Although the evidence is uncertain, EMFs have been reported to influence incidence of a variety of childhood and adult cancers and specific neurodegenerative diseases. A recent epidemiologic report indicates a possible association with some forms of heart disease.

Principal data needed for calculations of economic costs of disease are disease-specific incidence and mortality rates, and the costs of illness and death. Illness engenders both direct and indirect costs for which the "willingness-to-pay" and "human capital" methods have been developed as alternative ways to assign a monetary value for death and disease.

The theory of welfare economics supports the use of willingness-to-pay as the best measure of the social value of averting death and disease. Considerable controversy exists, however,

surrounding the two techniques (revealed preference and contingent valuation) that economists use to assess willingness to pay.

Although we present willingness-to-pay data in this report, we also use a more direct approach to estimating the monetary value of death and disease that combines (i) the medical costs of treating illness ("direct costs") and (ii) the economic value of lost productivity attributable to death and illness ("indirect costs"). Valuing death and disability on the basis of lost productivity of labor is referred to in the economics literature as the human capital method. The term "human capital method" also is used to refer to techniques that incorporate estimates of lost human capital in deriving the overall costs of illness and death. The advantages of using averted medical costs and averted productivity losses to value the benefits of life-saving policies are that data are more objective and readily available than for the willingness-to-pay method. In many circumstances, policy-makers find medical costs and productivity losses more direct and compelling as measures of loss than willingness-to-pay.

The human capital method for valuing the non-medical costs of premature death and disability is not without limitations. Using lost wages to value years of life lost places no value on lost years of childhood or retirement. Other limitations arise because not all impacts of disability and death are measured. Reduced quality of life, loss of companionship, pain and suffering, and dread associated with certain outcomes (for example, cancer, brain injury, and serious burns), although less easily quantified than medical costs or marketplace costs, are without doubt significant consequences of illness and death.

This report makes available data obtained with both the human capital and willingness-to-pay methods so that users of the decision analysis model can apply both types of cost estimation. In general, the human capital approach is used more frequently than the willingness-to-pay method. For example, Rice and Miller (1996) recently stated, "The human capital approach is still most often used in cost-benefit and cost-effectiveness analyses that seek to evaluate alternative demands for scarce health resources and promote economic rationality in health services policy, planning and management."

This report presents data suitable for economic analyses of potential health effects from EMFs in tables and accompanying computer files. These comprise an "EMF health costs database". The methods by which health cost-related data were obtained are described below. The data presented are only those needed for an economic analysis of issues raised by EMF exposures

in public schools and daycare centers. No independent estimates of disease risk related to exposures to electric and magnetic fields are given, but relative risks found in published work are quoted. Likewise, health costs are quoted from previous work and no new data were generated. The quoted values for all listed health risks, as for most costs, vary over a considerable range and cannot be considered definitive.

This work was performed as a project of the California Department of Health Services, administered by the Public Health Institute, and funded and authorized under direction of the California Public Utilities Commission. The decision analysis models developed in this project evaluate costs and benefits of a variety of school policy options that were developed in response to issues raised by the occurrence of EMFs in public schools and day care centers. The database is also a resource that can be adapted or augmented as necessary for future policy analyses. Cost information and identified disease endpoints were selected to meet a wide range of opinions on the magnitude of potential EMF health effects and their associated costs. The database is not based on a consensus list identifying the most-probable EMF-related diseases, nor were meta-analyses conducted to obtain summary risk estimates. A policy analyst may select from the health cost estimates presented here in order to model decisions based on particular disease endpoints, levels of risk, and the proportion of the population that is exposed.

The data presented in this report are for use in estimating aggregate health care, social, economic, and disease and disability costs potentially attributable to EMF exposures. Such cost estimates are necessarily imprecise because of unavoidable uncertainties in the incremental changes in risk with exposure (that is, the dose-response relation), disease prevalence, and the method for assessing costs in each category. For example, readers unfamiliar with the present state of knowledge may be surprised by the disparity in valuations of premature death obtained using various methods. In addition, the level of risk from EMF exposures, if any, is uncertain.

Identification of adverse health effects and estimation of associated costs involved three steps:

1. Potential adverse health effects (disease endpoints) that might be attributable to electric and magnetic field exposures were identified and placed on a list.
2. Rates of disease incidence or prevalence in the general population were obtained for each of the selected adverse health outcomes. These data establish estimated background disease levels.

3. Cost per case was estimated for several categories of identified adverse health effects. A variety of impact measures including mortality, disability, health care costs, and social and economic costs were considered.

Although calculation of the attributable fraction for EMF-related diseases would be needed for completion of a health costs analysis, attributable fraction estimations were not attempted in this report for several reasons. The principal reason is that a major goal of this project is policy development under guidance of *user-selected estimates* for excess risk, the population at risk, and the dose-response relationship. Because the user can choose from a range of risk estimates and other factors, an explicit calculation of the population attributable fraction is not needed as input data for the decision models. Moreover, making arbitrary choices for EMF risks, population at risk, and dose-response in order to generate attributable fraction estimates would give the appearance of undercutting major goals of the school policy project. The computer implementation of decision analysis modeling was developed for the California School Policy Project to permit rapid evaluation of several "What if?" scenarios. By choosing alternative risk scenarios, the user, in effect, makes various estimates of the attributable fraction. One goal of the project is to allow decision-makers to make choices using the model as a means to better understanding the bounds of the problem at hand. Therefore, it would be contrary to the purposes for which the model was developed to provide information that might be mistaken as a best estimate, when in fact none exists.

# Background and Rationale for Methods of Risk Estimation

## Goals for Selection of Listed Risk Estimates

The goals for this task were to develop a list of risk estimates that would be broad ranging, representative, and chosen from the more robust of the available data (e.g., based on studies having a large number of cases), whenever such a choice was possible. Consistent with these goals, the methods chosen for identification of items for the initial comprehensive listing were purposely non-restrictive, allowing consideration of a broad range of health effects. A separate step applied selection criteria that are described below to form a final list based on those data believed to be more reliable.

As just discussed, the risk estimates are to be used as input data to decision analysis models. In using these models a variety of possible and plausible risks can be evaluated in order to explore the costs for specific diseases potentially caused by EMF exposure and to calculate the benefits that might accrue from preventing harmful exposures. In light of these concerns, it is important to consider diseases like heart disease and female breast cancer that, although they have not been conclusively associated with exposure to EMFs, could be of great public health and economic significance because such diseases are very prevalent. Policy planners may need to consider the potential outcomes both for a small increase in risk for a common disease like heart disease, and for a possibly greater risk of a disease like brain cancer that is less common.

## Identification of Diseases Potentially Related to EMF

We are interested in diseases possibly associated with EMF exposures to both children and working-age adults because schools contain both students and adult staff. Tables 1–4 summarize the odds ratios that have been observed in past epidemiologic studies of child and adult populations. The list is broadly inclusive of diseases even where there is only weak evidence for a causal connection with EMFs, but the list does not include purely speculative associations. In drawing up the list, several major review articles were consulted and literature searches were made using the EMF Database V 2.0 (Information Ventures Inc., Philadelphia), the Medline Database (National Library of Medicine, Bethesda), Microwave News (1994-98, New York), and EMF Health and Safety Digest (1994-1996, Philadelphia). The list is based on epidemiologic evidence of a statistically significant association or a pattern of risk ratios greater than one. Risk ratios reported for diseases and syndromes were considered without requiring statistical

significance at the conventional level of probability, $P < 0.05$.[1] Animal studies and in vitro laboratory research were also evaluated for evidence of associations with specific diseases or dysfunctional syndromes which might be related to disease in human beings, but only the heart rate changes observed in human studies had not already been identified epidemiologically.[2]

**Criteria for Inclusion of Listed Diseases and Syndromes in Final List**

A final list was selected from the larger, comprehensive list by culling diseases that were cited speculatively or for which there are only isolated data, that is, non-replicated epidemiologic or laboratory findings, or non-replicated epidemiologic findings without supporting information from laboratory studies. The omitted diseases were cancer of the testicles, birth defects, neurasthenia, digestive disorders, and reduced libido. Also omitted were childhood intra-cranial and central nervous system tumors excepting brain tumor. It should be borne in mind that the primary goal of this task was to develop representative data on health costs for use in decision analytic modeling. Omission of specific diseases or syndromes is of little individual importance for this goal unless they are diseases of high prevalence in the population at large, for example, heart disease, lung cancer, or female breast cancer, and they are plausibly related to EMF exposures. Note that lung cancer was listed although there is little evidence to associate this disease with exposures to power frequency fields of the type found in schools and day care centers, and breast cancer was listed despite data which are at present conflicting and inconclusive.

Epidemiologic studies were reviewed to get risk estimates for listed diseases. For the purpose of assigning costs, four disease categories were defined: (1) childhood cancers, (2) adult cancers, (3) reproductive outcomes, and (4) non-cancer, non-reproductive diseases such as heart disease, amyotrophic lateral sclerosis (ALS), Alzheimer's disease, and depression. Risk

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1. This decision was made to assure a listing likely to include all diseases needing consideration now and in the near future and because statistical significance is a quality of a study and not a fixed descriptor of the truth or falsity of the observed risk ratio. Statistical significance is determined jointly by the magnitude of the observed risk ratio and the number of persons in the study. Therefore, a small study might accurately find an elevated risk ratio but because of its size, there could be little confidence in its accuracy. Therefore, a larger study may observe the same risk ratio but with lesser uncertainty.

2. Animal experiments with 50/60-Hz magnetic fields have led to hypotheses based on suppression of melatonin levels with potential effects on breast cancer and prostate cancer, among others. However, cancer of the breast has already been the focus of epidemiological research and various occupational

information obtained from a review of individual studies, meta-analyses, and review articles is represented in Tables 1-4. The tables show point estimates and associated confidence interval estimates for a wide variety of disease endpoints, adult, child and total populations, various methods of epidemiologic investigation, and various methods of exposure assessment. The tables show representative selections from the available data and attempt to show estimates that characterize the range of research results for a particular disease. These illustrative data are meant to capture the apparent risk estimates for the purposes of assessing health costs but *there has been no systematic effort to select data which would give a most likely estimator of risk for the various diseases listed*. In particular, there was no systematic procedure to represent null effects in accurate proportion to their epidemiologic importance. Neither has there been an attempt to weigh the relative quality of the research from which these estimates are quoted. The authors of this report exercised scientific judgment in choosing which of the available data were chosen to meet the goals for this tabulation.

The relative risks compiled in Tables 1 through 4 are based on a handful of convenient measures of EMF exposure, including wire codes, time-weighted averages and spot measurements. If EMF exposure does affect disease risk, the relationship between exposure and effect may be captured only weakly by the exposure measures that have been used in epidemiological studies to date. Such would be the case, for instance, if changes in field intensity were more important than long-term average exposure. If other measures of exposure are better than those used to date, then the relative risks in Tables 1-4 would underestimate the true risk to the most exposed individuals. Currently, there is no way to ascertain which exposure measure may be the best predictor of risk for a particular disease.

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epidemiologic studies have examined prostate cancer.

# Background on Methods of Cost Estimation

## Estimates of Costs of Disease

Two principal methods are used to capture the costs of lost life and lost productivity occurring as a result of accident or disease. The “human capital method” employs objective economic measures for the economic value of a member of society (Rice et al., 1985). Direct medical costs, and perhaps other costs, are added to the human capital valuation in order to obtain the full costs of illness or death. The “willingness-to-pay” method (Schelling, 1968; Mishan, 1971; Miller, 1989) employs economic data and “revealed preferences” that are determined by past societal choices and by expert elicitations from individuals. Miller (1989) identified two components of societal cost in the willingness-to-pay approach: "1) individual willingness to pay defined as the value a typical person places on health and safety, and 2) the cost the rest of society saves by preventing or controlling an injury." "…the first term [captures] how much people are willing to pay, and actually do pay, for safer and healthier lives. The second term, the savings society gains through injury prevention and control, includes increased tax revenues; reduced transfer payments in Medicare, food stamps, unemployment compensation, etc…"

Despite the successes of each method, valuation of the actual and societal costs of disease has proven difficult because of both practical and philosophical issues. Robinson (1986) traced the philosophical roots that distinguish these two methods to differing models for the role of governmental intervention for the advancement of social welfare. In Robinson’s view the human capital method is derived from the belief that government should, in most instances, take a laissez-faire role with respect to individual actions and to measure any proposed governmental actions in terms of cost-effectiveness and cost-benefit. Robinson concluded that despite any appearance of conflict between the two methods, “The important point is that both the human capital and the willingness-to-pay approaches can be valuable aids to public policy formulation, but neither should be allowed to substitute for it.”

## Cost of Illness by the Human Capital Approach

Table 5 lists objective economic measures and valuation methods needed for estimation of the costs of illness. Six factors consequent to illness and death are identified: 1) significance for health of the population; 2) significance for death in the population; 3) economic cost of disease; 4) severity of economic loss from death; 5) severity of economic loss from disability; 6) losses

from other diseases, events, and conditions causally related to the principal disease. Several of these are self-explanatory. The prevalence of a disease in a population is itself important as an indicator of population well-being just as the rate of deaths from a specific cause characterizes the population. In order to be useful for economic analyses, each factor must be measured in economic terms. In the USA, federal, state and local government maintain health statistics that provide direct measures of population health and mortality in terms of recorded numbers of incident and prevalent cases and the number of deaths from specific causes. However, these measures are not themselves in economic terms.

The various costs associated with disease are divided into those directly related to the illness, and indirect costs that flow from lost productive capabilities. The human capital method permits quantification of indirect costs in terms of the dollars that represent productivity lost to illness (morbidity costs) or death (mortality costs). For an individual, the direct costs of disease consist of medical costs for treatment and expenditures for social welfare to accommodate family and individual needs that result from disability or death. The major indirect cost of disability and death is the reduction in income that occurs because of full or partial inability to work productively. However, even if two diseases had the same treatment costs and led to the same annual loss of income to the individual, they might not have the same severity for society because of differences in the age at which cases occurred. In general, there is an additional factor, the degree of disability, which varies from disease to disease. Direct measures of the foregoing factors are the years of potential life lost, the dollar value of lost productivity (or, similarly, lost income), the number of years of total or partial disability, and quality-adjusted years of potential life lost. Potential years of life lost can be readily calculated from age-specific mortality, as done in this report. The value of lost productivity for men and women at ages from birth to 65 or 85 years of age has been estimated previously (Rice et al., 1989a). However, other data are more difficult to obtain. Unlike health statistics that can be obtained from hospital and death records, there are few sources for information about degree of disability and treatment costs, except for some common diseases.

**Willingness-to-Pay Methods**

Alternatively, social welfare theory respects societal values about a particular disease or injury independently of measurements of direct and indirect economic losses. One measure of such societal values and preferences is found in the cluster of factors comprising willingness-to-pay for

a variety of interventions. These factors and the measures used for willingness-to-pay are indicated in Table 6.

The first approach listed considers the amounts that historically have been spent to avoid specific diseases, disabilities, and accidents. The range of measures for such expenditures includes public health measures such as sanitation, inoculation against disease, pollution controls, and safety devices. The effectiveness of past expenditures can be gauged by the cost per life saved (for example, for automotive and highway safety improvements such as seat belts, air bags, breakaway lighting fixtures, etc.), or the cost per year of life saved (for example, to estimate the effectiveness of medical treatments such as drug therapy, surgery, heart pacemakers, and influenza inoculation of older persons).

A second class of payments involves steps taken to prevent or limit the impact of disease. Diagnostic tests such as mammography, cholesterol tests, and blood pressure measurements have significant costs when a large part of the population takes the tests. Their effectiveness is evaluated in terms of cost per case discovered, cost per life saved, and cost per year of life saved.

A third level of intervention is treatment after a disease is manifest. When used in the willingness-to-pay method, these costs are used to evaluate other costs. For example, American society finds it acceptable to spend $8,100 per life-year saved (Table 7) to place smoke and heat detectors in homes. This fact might be used to promote spending on engineering changes to reduce EMFs that, it could be argued, would have a similar cost per life-year saved. Or it might happen that the proposed engineering changes have a cost far greater than $8,100 per life-year saved and appear excessive.

**Valuation of Death and Illness Using Willingness-to-Pay Methods; Comparison with Cost-Effectiveness**

Viscusi (1993) reviewed past studies to obtain data for the value associated with death and disability in a number of contexts. Based on 24 samples of wage rates and job-related fatality risk, Viscusi found an implicit value for life that ranged from $0.6 million to $16.2 million in 1990 dollars and in many cases, valuations were in the range of several million dollars. Viscusi noted that the majority of estimates fell in the range of $3 to $7 million. Viscusi also considered data that did not depend on wage-determined methods of valuation. His sources resembled those used by Tengs et al. (1995). The picture from wage data is that the implicit value of life is lower, with all but one estimate falling below $2 million (1990 dollars). Surveys based on hypothetical questions

probing the value of life in risk scenarios such as those involving accidents with automobiles, airplanes, and on the job, revealed implicit valuations that were mostly above about $3 million (1990 dollars) but ranged from $0.1 to $15.6 million (a ratio of 156 to 1).

Tengs et al. (1995) presented a compilation of cost-effectiveness for over 500 life-saving interventions, many related to safety devices, medical interventions, and control of toxic agents. Table 7 lists selected data from their work to allow comparisons with costs of potential investments in health and safety, including EMF mitigation, being considered by policy analysts. Cost effectiveness data also can be compared to valuations on life elicited by willingness-to-pay methods. It can be seen from Table 7 that the range of costs per year-of-life-saved vary from trivial to very large amounts. Highly effective steps like vaccination against childhood disease have small costs, prevent relatively common diseases, and may even produce net economic gains by precluding health care costs that are greater than the costs of vaccination. At the other extreme are the examples of costly reductions in low-level, low-risk radiation emissions from nuclear power plants ($180 billion per life-year saved, in 1993 dollars), or the high cost ($2.8 million per life-year saved, in 1993 dollars) of outfitting school buses with seat belts to prevent a low-risk of fatal accidents. In cases, different analyses presented in Table 7 produce greatly different estimates of cost per life-year-saved. Studies of beta-blocker drugs for prevention of second heart attacks showed great differences depending on the age and medical status of the study group, with a range of nearly 50:1. Reduction of industrial exposures to benzene likewise produced estimates that varied by a factor of about 40:1.

**Valuing Health Benefits: Relationship of Policy Considerations to Health Cost Methodologies**

The principle that the costs of environmental health interventions should be commensurate with the health benefits they produce is hardly controversial. Yet defining how to measure, aggregate, and place a monetary value on the health benefits of a policy has proven to be a very thorny theoretical and public policy problem. There are two basic reasons for this difficulty. The first has to do with issues of distributive justice. Any summary measure of policy health benefit places implicit weights on benefits to different segments of the population. Population wide measures of disease incidence, for instance, assign equal weight to all. Alternatively, one could design measures that place relatively more weight on disease among the young, the frail, or the poor, to name a few.

The second difficulty in placing a value on the health benefits of a policy lies in placing a dollar value on those impacts. Three approaches to valuing disease impacts have been identified. In addition to economic impact (human capital) and willingness-to-pay valuations already discussed above in the context of the costs of disease, there is the option to place no valuation on health benefits of intervention. Those adopting this approach argue that placing a monetary value on the benefits of health interventions is so problematic that it shouldn't be done at all. They suggest that the costs of health interventions be compared against only the most direct measures of health benefit, such as the amount of disease, disability, and mortality avoided by the intervention. Others note that the direct economic benefits of reduced health damage can serve as a lower bound on the monetary value of environmental health interventions. These direct benefits include the averted costs of disease already given above in discussing the human capital method. The advantage of using the most direct economic factors (e.g. medical costs, wages) to place a monetary value on the benefits of health interventions is that such factors are relatively easy to measure or estimate, and they are intuitively appealing. However, these easily quantified direct benefits are disadvantageous because they capture only part of the policy impact, ignoring indirect benefits such as the value of freeing up caregivers' time and the value of increasing capacity to undertake and enjoy non-work activities. Economists caution that easily quantified measures of policy benefits such as averted medical costs and averted wage losses may not reflect peoples' personal utility trade-offs very well. The methods associated with willingness-to-pay for risk reductions have been designed to measure these additional health benefits (Fischhoff, 1991).

# Risk Estimates for Diseases Potentially Related to EMF Exposure

## Estimates for Incidence, Prevalence, Mortality, and Years of Life Lost for Diseases Potentially Related to EMF Exposure

A number of subsidiary calculations are needed in order to arrive at estimates of the total cost of a particular illness attributed to EMF exposure. For example, to obtain total direct costs per year for hospitalization, drugs, and surgery over one year for a newly diagnosed case, these costs per case must be multiplied by the number of incident cases. Alternatively, the number of prevailing cases and prevalence costs can be calculated. Prevalence costs estimate the economic impact of treating in one year all persons with a particular disease as contrasted with costs attributed to a newly diagnosed case. Likewise, estimates based on mortality require information on the number of deaths per year. Age at death is an important aspect of the toll taken by a disease. Based on age at death from a specific disease, the number of potential years of life lost (PYLL) can be calculated and used to estimate the economic impact of premature death.

Data on incidence, prevalence, and mortality were acquired from a variety of sources. The incidence of diseases potentially attributable to EMF exposure was obtained from the California Department of Health Services and other sources. Incidence data appear in tables 8, 9, and 10.1-10.2, both as the actual numbers of cases and as a rate per 100,000 persons in the population. Age-specific incidence rates for the five years 1989-1993 were obtained from the California Department of Health Services. These rates were applied to the 1970 Standard Million population to obtain age-adjusted rates for the entire population, childhood population, and adult population. This step was necessary for better estimates of disease incidence in the California population of children. Estimates for incidence in California in 1997 were calculated from the 1989-1993 California incidence data and the estimated California mid-1997 total population and from sub-populations (children, adults, adult males, or adult females) appropriate for various diseases. Incidence calculations, it may be noted, provide the expected number of cases from *all* causes, that is, regardless of any potential enhancement of risk from EMF exposure.

PYLL is used to estimate economic losses from premature death rather than as a measure of lost actuarial lifespan. These losses are represented by the earnings a decedent would have accrued had they lived until retirement age. In this report, PYLL is calculated by summing the number years of life lost before age 65 for all decedents, regardless of the fact that actuarial

lifespans are greater than 65 years. The economic loss corresponding to the PYLL is obtained in terms of the present value of future earnings calculated for an assumed discount rate. The discount rate takes into account the economic fact that future earnings are worth less in the present, or alternatively, that a sum of money held now would be expected to have greater value in the future. Typical discount rates range from 2 to 6%. A rate of 4% was adopted for use in this report.

**Attributable Fraction**

If exposure to an environmental agent such as EMFs is presumed to change the amount of a disease in society, it becomes necessary to estimate the attributable fraction, that is, the fraction of all cases of a particular disease that can be causally related to the environmental factor. Several data are needed for derivation of attributable fraction. These are the relative health risk from exposure to a given level of the agent, the degree and prevalence of exposures in society, size of the population at risk, and prevailing incidence or mortality rates for the disease in question. This report does not calculate attributable fractions for exposure to EMFs but does provide the information needed.

**Sources and Calculations for Tabulated Data on Incidence, Losses, and Costs for Selected Diseases**

Tables 9 and 10 give averaged age-specific incidences for selected diseases. Cancer incidence data were obtained from the California Department of Health Services, Cancer Surveillance Section. The data supplied were for all races and were aggregated for both genders, except in inappropriate cases such as female breast cancer and prostate disease. The information collected for this project can be found in three data files that are briefly described in Table 13. Sources and calculations used in creating the tables and data files are described in Appendix A.

**California School Population**

Table 12 provides census data for California school age children, teachers, school administrators, and staff that can be used to estimate the expected number of cases in California schools. This table is provided as a resource that is needed for calculations of attributable fraction (see below), but this report does not utilize these census data to estimate the potential number of cases in the school age population and school staff. The school policy decision model for which these data have been developed also requires these data.

# Cost Estimates for Diseases Potentially Related to EMF Exposure

## Background on Costs of Diseases Potentially Associated with EMF Exposures

This section presents estimates of the statewide and case-specific impacts of diseases that have been related to EMF exposures using the three most easily quantifiable impact measures: morbidity and mortality, direct medical costs, and lost earnings. Although medical costs and lost productivity represent only part of the total costs of disease, these are likely to be the two largest components for most diseases.

This project did not develop new methodologies for cost estimates nor acquire new data from medical care providers, but relied on previous research results that aggregated costs into two broad and inclusive categories, direct and indirect costs. Costs of illness reported by the National Institutes of Health (NIH, 1997) were used to provide representative costs for several disease categories (Table 8). Direct and indirect costs for selected illnesses from NIH (1997) included a diverse group of major diseases and accidents having a wide range of costs. These data permits policy analysts to infer the lowest and highest values likely to apply to EMF-related diseases.

In general, as the NIH (1997) report shows, data on costs of disease prevention and treatment costs are limited to some highly prevalent and well-studied diseases. Unfortunately, there are no comprehensive databases with data directly applicable to the majority of diseases and especially most of the diseases that are of interest for EMF exposures. This often makes it necessary, as indicated below, to make assumptions based about disease costs from similar illnesses.

## Costs for Specific Diseases Potentially Associated with EMF Exposures: Description of Entries in Table 8

Column 1 of Table 8 identifies the illness and source of the data (as a footnote). For Alzheimer's disease, data are given from two sources, allowing comparisons that illustrate more similarity than was apparent from the original data. Coronary heart disease, a large subcategory of heart disease that has been identified as possibly related to EMF exposure, is shown separately from other types of heart disease. Columns 2-4 list annual direct costs, annual indirect costs and their sums, annual total costs. All tabulated costs have been adjusted to 1997 dollar values using the Health Care Index (for direct costs), or the index for compensation per hour in the business sector (for indirect costs). Both indexes are from the US Bureau of Labor Statistics (see Table 11).

Columns 5 and 6 list the incidence rate or prevalence rate per 100,000 population per year except for perinatal conditions that are expressed per 1,000 live births per year. The total of cases shown in column 7 applies to incident or prevalent cases according to the entries in columns 5 and 6. The last three columns give the cost per case (1997 dollars) broken down into direct and indirect costs except where indirect costs are unavailable. The data for these costs is derived directly from the data of columns 2-4 and therefore rounding errors may cause small differences between the sum of direct and indirect costs and the indicated total.

**Costs of Disease for Specific Diseases Potentially Associated with EMF Exposures: General Features of Data on Cost of Illness**

Table 8 presents costs of a number of diseases that, according to some research, may be associated with exposures to EMFs. Although other data in this report are specific to California, national cost information was utilized because of greater availability for the diseases of interest and because national data are more up-to-date.

Because of the paucity of data on costs for specific diseases, especially uncommon diseases, Table 8 lists relatively fewer illnesses than those for which data on incidence and mortality were acquired. However, these costs span the range of illness categories potentially related to EMFs (cancer, degenerative diseases, heart disease, perinatal conditions) and fulfill the fundamental requirement for cost information suitable for guidance on school policy decisions.

It should be noted that disease cost information itself is acknowledged to be imprecise. For example, NIH (1997) wrote, "Cost of illness (COI) estimates provide order of magnitude indicators of the economic burdens imposed on society by various diseases and conditions." As a consequence of imprecision that may be as great as factor of ten if the phrase "order of magnitude" is taken literally, it would be unrealistic to pursue detailed cost data on each sub-category of the illnesses treated in this report. For the purposes of the policy analyst, representative costs of illness such as those in Table 8 should suffice.

Table 8, like the data from which it is derived, gives prevalence-based costs. Cost in one year ("annual cost") is based on all cases existing in that year. Thus, those new and old cases that require hospital and medical treatment contribute to the direct costs, and those that are disabled or die contribute to indirect costs. For deaths, the present year value of the decedent's productivity is calculated from the average annual value of lost productivity (usually taken as average income), the number of years of potential life lost, and a discount rate to adjust for the present value of

future income. In some of the source data, costs of disability (lost productivity) also have been included.

An alternative to prevalence-based costs is incidence-based costs. In this case incident cases are enumerated and the projected lifetime costs for the new cases are estimated. Calculation of lifetime costs can include the same source information on direct and indirect costs as used in prevalence-based accounting, but requires additional information such as duration of the disease condition, survival rates, and the economic severity of disability. The greater difficulty of incidence-based costing has led to less use of this method, although the greater detail of subsidiary information permits better analyses of the value of particular health intervention strategies. For example, data derived from incidence-based studies can help to choose among drug and surgical treatments or to select the more efficacious strategies for diagnosis and prevention.

**Costs for Specific Diseases Potentially Associated with EMF Exposures: Costs in USA (1997)**

Refer to Table 8 for the data discussed in this section.

All cancer. Using a 4% discount rate, the 1997 total cost for all cancer in USA was $126.2 billion ($39.6 billion in direct costs, $86.5 billion in indirect costs). Overall, in 1997 there were an estimated 534,300 deaths, and 1,019,000 new cases of cancer. Direct costs included the costs of premature death and indirect costs for lost patient workdays, but not costs for lost productivity, healthcare services given by unpaid caregivers, and ancillary costs. By comparison, these data from NIH are in general agreement with National Cancer Institute estimates of 1,228,600 new cancer cases in 1998, 564,800 cancer deaths, and overall cancer costs of $107 billion of which $37 billion are direct costs, $11 billion in morbidity costs (lost productivity), and $59 billion in mortality costs (lost productivity) (National Cancer Institute, 1998). From Table 8, the NIH data show a resulting 1997 cost per case of $123,900. The all cancer category includes both solid tumors and hematopoietic tumors (that is, leukemia and other blood cancers). See NIH (1997) for details of the data presented therein and a discussion of important limitations in the data.

Breast cancer (female). Using the same discount rate, total costs were $17.3 billion ($9.5 billion in direct costs, $7.8 billion of indirect costs). The 1997 cost per case was $121,500.

Prostate cancer (male). Direct costs of $6.8 billion, but no indirect costs were reported. The 1997 direct cost per case was $37,000.

Lung cancer. Direct costs of $7.3 billion, but no indirect costs were reported. The direct cost per case was $45,200.

Allergy. Adjusted for 1997, allergic rhinitis ("hay fever") was estimated to have cost $2.5 billion ($1.7 billion in direct costs, $0.8 billion in indirect costs) (NIH, 1997). There were no mortality costs, but indirect costs included lost workdays and reduced productivity. The 1997 total cost per case receiving medical attention was $470. The estimated prevalence of allergic rhinitis was based on 1987 data corrected for population growth assuming linear proportionality between USA population and prevalence of this condition. On this basis, 5.3 million persons sought medical treatment out of a total of 43 million persons suffering from allergic rhinitis. For comparison, Malone et al. (1997) estimated total costs (1994 dollars) of $1.23 billion (95% CI $846 million to $1.62 billion) of which direct medical expenses were 94%. Adjusted to 1997 dollars, the estimate from Malone et al. is $1.4 billion, considerably lower than the $2.5 billion estimate from NIH.

Alzheimer's disease. Estimated total and direct costs per case of Alzheimer's disease adjusted to 1997 dollars were $210,200 and $63,100 (4% discount rate), respectively, with annual direct and indirect prevalence costs of $27.3 billion and $81.3 billion, respectively (Ernst and Hay, 1994). The total cost was $108.7 billion per year.

Earlier data from NIH (1997) indicated 18,600 deaths annually from Alzheimer's disease and other dementias with total costs adjusted to 1997 dollars of $143.9 billion ($27.5 billion direct, $116.4 billion indirect) for the population aged 65 years or more. Direct costs included premature death and indirect costs included lost workdays and healthcare services given by unpaid caregivers. These data lead to an estimated 1997 total cost per case of $291,100 of which $55,600 was direct costs. The agreement between these estimates and those taken from Ernst and Hay (1994) is good. The two studies yield comparable estimates for direct costs but differ by about one-third in estimates of indirect costs.

Multiple sclerosis. Obtained using a 6% discount rate, the total cost (1997 dollars) of $6.8 billion ($3.6 billion direct, $3.1 billion indirect) included direct costs due to premature death, and indirect costs for lost patient workdays, but not for lost productivity and healthcare services given by unpaid caregivers. The cost per case (1997 dollars) was $22,500.

Perinatal conditions. Direct costs (1997 dollars) for perinatal conditions, preterm delivery, and low birth weight were estimated at $2.3 billion in direct costs. The approximate cost per case in 1997 dollars was $8,100. Mortality costs were not considered.

**Limitations of Cost Estimates in Tables 8, 9 and elsewhere in this Report**

It is important to understand the limitations of these cost estimates. As noted by NIH (1997), "Cost of illness estimates provide order of magnitude indicators for the economic burden of disease and should be interpreted with caution. They neglect other equally important but difficult to measure dimensions—such as prevalence of disease, and the effect on the quality of life and daily functioning—in considering and understanding the true cost of illness to society." See this source for additional important caveats including uncertainty, judgments made in treating missing data, large methodological differences between various component studies, incomparability of data across disease categories, discount rates, disease definitions, selected cost components, and reference years.

Costs given by NIH (1997) were determined on the basis of disease prevalence, that is, annual costs rather than costs for the entire duration of a disease condition lasting more than one year. In the absence of data for the number of prevalent cases in many instances, costs per case were obtained by division of total cost for a specific illness by the number of incident cases. See Table 9. The incidence, death and cost rates found in Tables 8 and 9 were applied to the 1997 California population for the calculations summarized in Table 9. The goal here was to obtain representative data for health care costs of diseases that may be presumed to have costs similar to those of diseases potentially attributable to EMF exposure.

**Adjustments for Changes in Value of the Dollar**

Health costs listed in this paper come from a variety of sources that were prepared at various times during the past ten or more years. Adjustments for the change in the value of the dollar ("inflation") were made on the basis of price indexes available from the U.S. Bureau of Labor Statistics. The Medical Care Index (Consumer Price Index for All Urban Consumers) was used to adjust direct medical costs to mid-year 1997 dollars. Lost economic productivity was adjusted to 1997 dollars using the index for hourly compensation in the business sector (Table 664, Statistical Abstract of the United States).

For convenience in comparing data in this report with other data, consumer price index values over the past 16 years are presented in Table 11. The consumer price index (CPI) was based on a U.S. urban average with the value of the dollar during the base period 1982-84 set to 100. Table 11 shows indexes for the years 1982 to 1997. It may be noted that over this time span there was considerably greater growth in prices for medical care compared to general consumer prices. In fact, for the 16-year period from 1982 to 1998 these two indexes stand in the ratio of 1.50:1, which indicates a 50% excess of inflation for medical costs over inflation in general prices.

**Comparison of California Cancer Costs and USA Cancer Costs**

For comparison and evaluation of the possible significance of substituting national data for those of California, comparative health cost data from 1985 were consulted (Rice et al., 1989a). In their study, Rice et al. (1989a) noted that in comparison with USA cancer health costs, California cancer costs were a smaller proportion of all costs of illness (9.2 vs 10.7%). In California the percentages of direct, morbidity, and mortality costs were 30, 12, and 58% respectively, but for the USA (1985) the corresponding distribution of costs was 25, 10, and 65%. Estimated 1985 direct costs in California were $47,700 per death, a larger share, by a factor of one-fifth, than direct costs of $39,200 nationally. However, California's indirect costs were $10,000 less so that upon adding direct and indirect costs, overall 1985 cancer costs per death were estimated to be $1600 *less* in California than in the USA; the average cost per cancer death in California (1985) was $139,900 and in the USA $141,500. In consideration of the overall uncertainties of the data and procedures for extrapolation, a difference of 1%, as occurred here, can be ignored. Although there are, no doubt, real current cost differences between California and the USA, the study by Rice and colleagues (1989a) indicates that such differences fall well within the range of uncertainties that inform cost data in general.

**Pupil and Staff Population of California Public Schools**

To enable policy analysts to assess costs to school populations or sub-populations, pupil enrollment in California public schools was obtained (Table 12). In 1996-97 from kindergarten to grade 8 the overall pupil population was 4,053,885 (California Department of Education, Educational Demographics Unit). There were 1,559,080 pupils in grades 9-12. Total pupil population was 5,612,965. There were 257,988 teachers and 159,028 administrative staff.

# Appendix A. Sources and Calculation Techniques for Tabulated Information on Disease Incidence and Health Costs in California

The goal for compilation of incidence and mortality data was to obtain information to serve the needs of school policy models and not to establish precise risk estimates and precise costs. For the purpose of input to the models, treatment of secular trends in disease rates and distinctions based on gender and specific age, among other considerations, are not warranted and were ignored. In general, information was obtained for the most recent available period with the result that the data used cover a variety of years.

Age-adjusted incidence rates in California of selected cancers were estimated separately for children (zero to 19 years of age) and adults (greater than 20 years of age). Data on the incidence of cancer at specific sites over the five-year period 1989-1993 were obtained from the Cancer Surveillance Section (CSS), California Department of Health Services. These data provided incidence rates by age grouped in five-year intervals. Incidence for both genders was summed except for breast cancer and prostate cancer, which have greatly different incidence rates for the two sexes. Overall age-adjusted rates were available in the CSS data, but age-adjustment was re-calculated in order to derive age-adjusted rates for children and adults. In addition, a comparison of our calculations for overall age-adjusted rates with those of CSS served to validate the accuracy of data import and calculations. Finally, the calculated child and adult incidence rates were used to estimate total numbers of cancer cases based on the 1997 California population. See Table 9.

Non-cancer incidence rates for diseases for a variety of disorders were obtained from a variety of sources that are documented in Table 4.

Deaths from all causes in California in 1991 were obtained from the California Department of Health Services. Numbers of deaths in each age group were available in five-year intervals from birth to over 100 years of age according to ICD ninth revision code numbers and ranges of code numbers. These data were used to calculate age-adjusted mortality rates for adults, children, and all ages. Mortality from all forms of leukemia was determined by summation of deaths in California for ICD codes 204, 205, 206, 207, 208.

Indirect mortality costs were estimated from age-specific mortality and age-specific values for the present value of future earnings lost because of premature death. Mortality in each age

group was used to obtain the total of years of potential life lost (PYLL) prior to age 65. Future earnings were discounted at an annual rate of 4%.

Detailed information for deaths during the neonatal and postnatal periods, including deaths related to birth defects and infants of low birth weight, were obtained from the California Department of Health Services. These data also are the basis for estimates of direct and indirect costs of deaths that might be attributed to EMF exposure (see below).

In addition to the 1991 data for deaths attributed to Alzheimer's disease in California, age-adjusted death rates for 1979-91 from this disease also were obtained from the Centers for Disease Control and Prevention, US Department of Health and Human Services.

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# Appendix C. Bibliography for Cost of Illness and Methods for Determining Health-related Costs


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# Tables

**Table 1. Representative Odds Ratios for Potential EMF-Related Childhood Cancers**

| Disease | Risk Est. (95% CI)[a] | Notes | Source |
|---|---|---|---|
| All cancers | 1.3 (0.6-2.7) | Calculated magnetic fields 0.3 μT based on historical records for 2 cases. | Feychting and Ahlbom (1993) |
| | 2.2 (1.6-3.1) | HCC v LCC wire code for 129 cases. HCC wire code. Magnetic field at front door 0.3 μT for 34 cases | Wertheimer and Leeper (1979) |
| | 2.1 (1.1-4.0) | Calculated MF 0.25 μT for 6 cases MF 0.25 μT [e] | Tomenius (1986) |
| | 1.5 (0.6-4.1) | | Olsen et al. (1993) |
| All leukemia | 1.48 (1.18-1.85) | Meta-analysis of four wire code studies (random effects model) based on a LCC cutpoint. | NRC (1996), Table 5.4. |
| | 0.92 (0.57-1.49) | Meta-analysis of four studies based on spot measurements of fields (random effects model) with a cutpoint at 0.2 μT | NRC (1996), Table 5.4. |
| | 1.37 (1.07-1.75) | Meta-analysis of 10 studies using cutpoints that select the highest exposures. | NRC (1996), Table 5.4 |
| | 3.8 (1.4-9.3) | Historical calculated fields with a cutpoint at 0.3 μT. For a 0.2 μT cutpoint, OR = 2.7 (95% CI 1.0-6.3) | Feychting and Ahlbom (1993) Linet et al. (1997) |
| | 1.24 (0.86-1.79) | Time-weighted average magnetic field strengths >0.2 μT, unmatched analysis | Linet et al. (1997) |
| | 1.53 (0.91-2.56) | Time-weighted average magnetic field strengths >0.2 μT, matched analysis | Linet et al. (1997) |
| | 0.88 (0.48-1.63) | VHCC homes compared with the lowest wire code category as reference | |
| Acute lymphocytic leukemia | | | |
| | 1.28 (0.70-2.34) | Two-level wire code at time of diagnosis | Savitz et al. (1988) |
| Lymphoma | 2.1 (0.8-5.2) | HCC v LCC wire code (18 cases with HCC homes at death address) | Wertheimer and Leeper (1979) NRC, 1996, Table A5.6 |
| | 3.2 | Adjusted OR for low-power MF >0.2 μT (based on 2 cases from Savitz et al. (1988) | Feychting and Ahlbom (1993) |
| | 1.3 (0.2-5.1) | Calculated magnetic fields 0.2 μT based on historical records (2 cases). | |
| Brain tumor | 2.4 (1.2-5.0) | HCC v LCC wire code at death addresses, 30 HCC cases. | Wertheimer and Leeper (1979) Tomenius (1986) |
| | 3.9 (1.1-13.7) | MF 0.3 μT at front door (13 cases) | Olsen et al. (1993) |
| | 1.0 (0.2-5.0) | Calculated MFs 0.25 μT (2 cases) | Feychting and Ahlbom (1993) |
| | 0.7 (0.1-2.7) | Calculated historical MFs 0.2μT | Feychting and Ahlbom (1993) |
| | 1.0 (0.2-3.9) | Calculated historical MFs 0.3 μT | |

Notes:

[a] Unless otherwise indicated Odds Ratios are shown with 95% confidence interval (CI) in parentheses.

[j] Matched analysis, OR = 1.53 (95% CI 0.91-2.56).

**Table 2. Representative Risk Estimates for Potential EMF-Related Adult Cancers**

| *Disease* | **Risk Est. (95% CI)**[a] | **Notes** | **Source** |
|---|---|---|---|
| All cancer | 2.2 (1.5-3.2) | Based on 108 cases with VHCC wire code | Wertheimer and Leeper (1982) |
| | 103 (68-150)[b] | Based on 27 observed cases of all ages living within 14 m of an electrical facility | McDowall et al. (1986) |
| | 85 (63-114)[b] | Based on 46 cases of all ages with high exposure levels (0.1 – 1.1 μT). | Schreiber et al. (1993) |
| Leukemia | 1.6 (0.5-5.0) | Low power MF measurement >0.2μT | Severson et al. (1988) |
| | 1.0 (0.7-1.7) | Historical estimated MF 0.2μT | Feychting and Ahlbom (1994) |
| | 1.9 (0.8-4.4) | Estimated MF for 15 cases 0.3 μT | Youngson et al.., 1991 |
| Chronic lymphocytic leukemia | 1.9 (1.0-3.8) | Combined occupational studies | Feychting et al. (1997) |
| Acute myelogenous leukemia | 1.46 (1.27-1.64) | Pooled analysis | Thériault et al. (1995) |
| | 2.4 (0.95-6.0) | | Cartwright et al. (1988) |
| | 0.93 (0.71-1.18) | | Verkasalo (1997) |
| Lymphoma | 130 ($p<0.05$)[c] | SIR, 81 cases | Linet et al. (1993) |
| | 68 (35-119)[c] | SIR | Tynes et al. (1994) |
| | 164[d] | PMR | Milham (1985) |
| | no excess risk observed | | Verkasalo (1997) |
| Brain cancer | 1.3 (1.0-1.7) | Electr. workers (typical) | Loomis and Savitz (1990) |
| | 1.7 (1.2-2.5) | Electrical workers | Preston-Martin et al. (1993) |
| | 0.95 (0.54-1.69) | Electric utility workers | Harrington et al. (1997) |
| | 1.54 (0.85-2.81) | Electric utility workers | Thériault et al. (1995) |

| *Disease* | **Risk Est. (95% CI)**[a] | **Notes** | **Source** |
|---|---|---|---|
| Glioma | 1.8 (0.7-4.8) | Los Angeles electrical workers | Preston-Martin (1989) |
| | 90[c] | SIR, electricians & electronic workers | McLaughlin et al. (1987) |
| | 2.11 (0.77-5.8) | EMF-exposed workers | Speers et al. (1988) |
| | no excess risk observed | Occupational exposures | Feychting and Ahlbom (1994) |
| Astrocytoma | 10.3 (1.3-81) | Occupational study | Mack et al. (1991) |
| | 1 (no excess risk observed) | Occupational exposure 0.2 µT | Feychting et al. (1997) |
| | 2.2 (0.6-8.5) | Occupational & residential exposure >0.2µT | Feychting et al. (1997) |
| | 12.29 (1.05-143.5) | Occupational exp. > 15.7 uT-yr, unadjusted for SES | Thériault et al. (1994) |
| | 1.53 (0.38-6.25) | As above, adjusted for SES | Thériault et al. (1994) |
| Neuroblastoma | 2.13 ( n/a ) | Occupational exposures | Spitz and Johnson (1985) |
| | 1.3 (0.4-4.1) | Occupational exposures | Bunin et al. (1990) |
| Breast cancer (female) | 1.38 (1.04-1.82) | Electrical workers | Loomis et al. (1994) |
| | 1.43 (0.94-2.17) | Nightly electric blanket users | Vena et al. (1994) |
| | 1.43 (0.99-2.09) | Occupational study | Coogan et al. (1996) |
| Breast cancer (male) | 207 (107-361) [c] | SIR, occupational study | Tynes and Anderson (1990) |
| | 1.8 (1.0-3.7) | Occupational study | Demers et al. (1991) |
| Prostate cancer (male) | 2.38 (1.13-5.01) | Electrical power worker for 10 y (11 cases). No association for <10 y work experience | Aronson et al. (1996) |
| | 1.67 (CI 0.84-3.31) | Electric utility linemen | Kelsh and Sahl (1997) |

| *Disease* | **Risk Est. (95% CI)**[a] | **Notes** | **Source** |
|---|---|---|---|
| Lung cancer | 3.11 (1.60-6.04) | Electric utility lineman (84 cases) | Armstrong et al. (1994) |
| | 1.15 (0.90-1.47) | Electric utility lineman; but the second, higher, level of cumulative exposure was not associated with a higher odds ratio. | Savitz et al. (1997) |
| | 1.43 (CI 1.23-1.67) | Electric utility workers at two lagged cumulative exposure levels. N.B., odds ratio for 2nd (higher) exposure is not greater. | Savitz et al. (1997) |
| | 1.25 (CI 1.02-1.52) | | |
| Melanoma | 224 [c] | SIR, electrical workers, but no dose-response | Tynes et al. (1994) |
| | no excess risk observed | Occupational study | Verkasalo et al. (1997) |

Notes:
n/a, Not available
a Unless otherwise indicated, odds ratios are shown with 95% confidence interval (95% CI) in parentheses.
b Standardized mortality ratio (95% CI).
c Standardized incidence ratio (95% CI).
d Proportional mortality ratio.

**Table 3. Representative Odds Ratios for Reproductive Outcomes Potentially Related to EMF Exposure**

| *Reproductive Outcome* | **Risk Est. (95% CI)** [a] | **Notes** | **Source** |
|---|---|---|---|
| Spontaneous abortion | 1.74 (0.96-3.15) | Electric blanket users | Belanger et al. (1998 ) |
| | 157 [b] | Maximum PIR (est.) | Wertheimer and Leeper (1989) |
| | 1.47 ($p<0.05$) | Occupational after 16 wks | McDonald et al. (1988) |
| | 2.3 (0.8-6.3) | Residential exp. 0.2 µT | Savitz and Ananth (1994) |
| Early pregnancy loss | 1.20 ($p<0.05$) | Occupational exp., before 16 wks. | McDonald et al. (1988) |
| Low birthweight for gestational age (intrauterine birth retardation) | | High settings of electric blanket at: | Bracken et al. (1995) |
| | 1.32 (0.82-2.11) | Conception | |
| | 1.55 (0.98-2.44) | 16 wks gestation | |
| | 1.59 (0.97-2.62) | 3rd trimester | |
| | 0.62 ((0.16-2.31) | Home magnetic field 0.2 µT | |
| | 1.16 (0.43-3.11) | 7-day monitor mag. field 0.2 µT | |
| Low birthweight (<2500 g) | | High settings of electric blanket at: | Bracken et al. (1995) |
| | 1.09 (0.56-2.11) | Conception | |
| | 1.23 (0.65-2.33) | 16 wks gestation | |
| | 1.18 (0.55-2.52) | 3rd trimester | |
| | not calculable | Home magnetic fields 0.2 µT | |
| | 1.35 (0.30-6.11) | 7-day mag. field monitor 0.2 µT | |

Notes:

[a] Unless otherwise indicated Odds Ratios are shown with 95% confidence interval (95% CI) in parentheses.

[b] Proportional incidence ratio. Value shown as if a Proportional Incidence Ratio is the ratio of fetal losses in homes with ceiling heat (~1 µT) for the four months ("season") with most fetal losses, to the expected number of losses in that season (q.v., Wertheimer and Leeper, 1989). Expected losses were adjusted for the proportion of live births in the period 8 months earlier as a crude adjustment for the number of first trimester pregnancies in the season of fetal loss. This calculation was based on data in the author's Table 2, Section 2, and resembles a calculation described by the authors, but Wertheimer and Leeper (1989) did not publish this calculation.

**Table 4. Representative Odds Ratios for Non-Cancer, Non-Reproductive Diseases and Symptoms Potentially Related to EMF Exposure**

| *Disease* | **Risk Est. (95% CI)** [a] | **Notes** | **Source** |
|---|---|---|---|
| Amyotrophic lateral sclerosis (ALS) | 2.5 (0.86-0.81)<br>2.3 (0.80-6.6)<br>7.5 (1.4-38.1)<br>5.5 (1.3-22.5) | Total occupational exposure > 75$^{th}$ percentile<br>Average occupational exposure > 75$^{th}$ percentile<br>Total exposure >75$^{th}$ percentile and 20y work<br>Average exposure >75$^{th}$ percentile and 20y work<br>Occupational exposure categories:<br>High (average >1 µT; or intermittently >10 µT);<br>Medium (average >0.2µT , < 1µT; or intermit-tently 1µT);<br>Low (average 0.2µT) | Davanipour et al. (1997) |
| | 3.0 (1.0-9.2) | Occup. exposure > 50$^{th}$ percentile | Savitz et al. (1997) |
| Alzheimer s disease | 2.9 (1.6-5.4) | Summary of 3 studies for med and high exposure | Sobel et al. (1995) |
| | 2.4 (0.8-6.9)<br>2.7 (0.9-7.8) | For exposure 0.2 µT in last job vs control #1<br>For exposure 0.2 µT in last job vs control #2 | Pedersen et al. (1996) |
| Cardiac: arrhythmia | 1.6 (1.0-2.4)<br>1.3 (0.8-2.0)<br>1.2 (0.8-2.0)<br>2.4 (1.5-3.9) | Exposure: 0.6 to 1.2 µT-years<br>0.6 to 1.2 µT-years<br>0.6 to 1.2 µT-years<br>4.3 µT-years | Savitz et al. (1998) |
| Cardiac: acute myocardial infarct | 1.1 (1.0-1.3)<br>1.2 (1.1-1.3)<br>1.4 (1.2-1.5)<br>1.6 (1.5-1.8) | Exposure: 0.6 to 1.2 µT-years<br>0.6 to 1.2 µT-years<br>0.6 to 1.2 µT-years<br>4.3 µT-years | Savitz et al. (1998) |
| Central nervous system disturbance | n/a | No risk information available. | |

| *Disease* | **Risk Est. (95% CI)** [a] | **Notes** | **Source** |
|---|---|---|---|
| Depression | 2.0 (0.8-4.9) | Among electrical workers (<10y) | Savitz et al. (1994) |
| | no increased risk | Common depression | Verkasalo et al. (1997) |
| | 4.7 (1.70-13.3) | Severe depression, subjects living <100 m of a high-voltage power line | |
| | 0.94 (0.48-1.8) | Women living near HVTLs (homes with magnetic fields at easement of ~0.48 µT vs. 0.068 µT). | McMahan et al. (1994) |
| | 2.6 (1.6-4.4) | Residents adjacent to powerline corridors | Poole et al. (1993) |
| Suicide | n/a | Distribution of electric & magnetic fields reported to correlate with suicide | Reichmanis et al. (1979) |
| | 430 (86-1250) [b] | SMR, train crew and power stations operators | Nakagawa (1994) |
| | 140 | PMR, measured magnetic fields 0.1µT using control group for reference | Perry et al. (1981) |
| Headache | 1.3 (0.55-2.8 CI) | Non-migraine type | Poole et al. (1993) |
| | 2.0 (0.49-8.0) | Migraine type | Poole et al. (1993) |
| Circadian rhythm disturbance | no effects | Exposure to 10µT, 50-Hz | Selmaoui et al. (1996a,b; 1997) |

Notes:
[a] Unless otherwise indicated Odds Ratios are shown with 95% confidence interval (CI) in parentheses.
[b] Standardized mortality ratio (95% CI).

**Table 5. Objective Economic Measures of the Cost of Illness and Death**

| Factor | Measures |
|---|---|
| Significance for population health | Number of cases<br>Incidence or prevalence of disease applied to population at risk |
| Significance for population mortality | Number of deaths applied to population at risk |
| Economic cost of disease | Medical care costs<br>Social welfare costs<br>Lost productivity (dollar value) |
| Economic severity of death | Years of potential life lost<br>Lost potential productivity (dollar value) |
| Economic severity of disability | Years of disability; quality-adjusted years of life lost |
| Other disease-related losses | Secondary diseases attributable to therapy for initial disease. (Includes cancers at sites unrelated to the initial cancer site) |

**Table 6. Willingness-to-Pay Measures of the Cost of Illness and Death**

| Factor | Measure of Value |
|---|---|
| Payments and Costs Incurred to Avoid Disease, Disability, Accident, or Death (Primary Interventions) | Historical examples of direct intervention costs (e.g., costs of inoculation against disease, sanitation measures, safety devices, pollution controls)<br>Cost per life saved<br>Cost per year-of-life-saved |
| Payments to Limit Impact (Secondary Interventions) | Historical examples of intervention costs (e.g., diagnostic costs such as mammography, blood tests, genetic tests)<br>Cost per life saved; Cost per year of life saved |
| Treatment Costs (Tertiary Interventions) | Historical examples of treatment costs (e.g., surgery, drugs, prosthetics, rehabilitation therapy) |
| Avoidance Payments | Expert Elicitations From Defined Cohorts<br>Perceived acceptable monetary payment (absolute value)<br>Perceived relative value of one intervention vs. another<br>Higher costs of food and other commodities<br>Public health education programs |
| Contingency Payments | Insurance premiums for death or disability<br>Acceptance of higher risks for higher wages |

**Table 7. Selected costs for life-saving interventions from Tengs et al., (1995)**

| Reference number* | Life-saving intervention | Cost/life-year (1993 dollars) |
|---|---|---|
| 175 | Mandatory seat belt use and child restraint law | 98 |
| 306 | Federal law requiring smoke detectors in homes | 920 |
| 19 | Smoke and heat detectors in homes | 8100 |
| 292 | Flammability standard for children's sleepwear size 7-14 | 45,000 |
| 12 | " " " " | 160,000 |
| 1124 | Seat belts for passengers in school buses | 2,800,000 |
| 1124 | Pedestrian education programs for school bus passengers in grades K-6 | 280,000 |
| 1139, 721 | Benzene exposure standard of 1 ppm vs. 10 ppm in various industries | 76,000, 240,000, 3,000,000 |
| 42 | Chlorination of drinking water | 3,100 |
| 468 | Automatic collimators on X-ray equipment to reduce radiation exposure | 23,000 |
| 468 | Radiation emission standard for nuclear power plants | 180,000,000 |
| 1266 | Radon remediation in homes with levels 21.6 pCi/L | 6,100 |
| 1267 | Radon remediation in homes with levels 8.11 pCi/L | 35,000 |
| 1265 | Radon remediation in homes with levels 4 pCi/L | 260,000 |
| 952, 176 | Beta-blockers for various groups of myocardial infarction survivors | 360, 850, 3,000, 17,000 |
| 142 | Mammography for women age 50 | 810 |
| 283, 658, 611, 1230, 86 | Annual mammography, sometimes in combination with breast exam, for various ages above 35 | 2,700 to 190,000 |
| 65, 143, 349, 812, 1178 | Various childhood immunizations (pertussis, diphtheria, tetanus, measles, mumps, rubella, polio) | 0 |
| 455 | Influenza vaccination for all citizens | 140 |
| 605 | Cholesterol screening for boys age 10 | 6,500 |
| 358 | Pacemaker implant (vs. medical mgmt.) for AV heart block | 1,600 |
| 251 | Mitral valve reconstruction surgery (symptomatic pts.) | 6,700 |
| 544 | Heart transplantation for pts. 55 y and good prognosis | 3,600 |
| 835 | Heart transplantation for pts. 50 y and terminal disease | 100,000 |
| 1095 | Bone marrow transplantation for adult ANL leukemia | 20,000 |

* Reference number identifies the study from the reference list in Tengs et al., 1995.

## Table 8. Annual Costs of Selected Illnesses in the USA (1997)*

| | Annual Rate | | | Cost per Case ($) | | | Cost ($ Billion) | | |
|---|---|---|---|---|---|---|---|---|---|
| Illness | Incidence¶ | Prevalence¶ | Cases% | Direct | Indirect | Total | Direct | Indirect | Total |
| Heart Disease (1) | | 8,332 | 1,764,748 | 53,200 | 37,600 | 90,900 | 94.0 | 66.4 | 160.3 |
| Coronary Heart Dis. (1) | | 5,194 | 1,100,000 | 43,700 | 37,800 | 81,500 | 48.1 | 41.6 | 89.7 |
| All Cancer (2) | 381 | | 1,018,688 | 38,900 | 85,000 | 123,900 | 39.6 | 86.5 | 126.2 |
| Breast Cancer (female) (2) | 105 | | 142,575 | 66,700 | 54,800 | 121,500 | 9.5 | 7.8 | 17.3 |
| Prostate Cancer (male) (2) | 138 | | 183,211 | 37,000 | NA | NA | 6.8 | NA | NA |
| Lung Cancer (2) | 61 | | 162,765 | 45,200 | NA | NA | 7.3 | NA | NA |
| Allergy (3) | | 1,981 | 5,301,197 | 330 | 143 | 470 | 1.7 | 0.8 | 2.5 |
| Depressive disorders (1) | | 9,500 | 15,795,059 | 1,816 | 837 | 2,653 | 28.7 | 13.2 | 41.9 |
| Alzheimer's Disease (2,4) | 185 | | 494,388 | 55,600 | 235,500 | 291,100 | 27.5 | 116.4 | 143.9 |
| Alzheimer's Disease (5) | NA | | 516,898 | 63,100 | 147,100 | 210,200 | 27.3 | 81.3 | 108.7 |
| Multiple Sclerosis (2,6) | | 112 | 300,000 | 12,000 | 10,500 | 22,500 | 3.6 | 3.1 | 6.8 |
| Perinatal conditions (7) | | 72 | 288,817 | 8,100 | | | 2.3 | | |

Notes:

USA resident population, July 1, 1997, 267,636,000 (estimated, U.S. Bureau of the Census).

* Costs are expressed in 1997 dollars by adjustments based on the hourly wage index (business sector) (applied to indirect costs) or Consumer Price Index for Medical Care (applied to direct costs). "Cases per Year", "Direct Cost per Case", and "Total Cost per Case" are based on 1997 USA population. Note however that the underlying data were collected at various times before 1997.

¶ Rate per 100,000 persons per year except "Perinatal conditions" (see note #7 below). Breast cancer and prostate cancer rates apply to only females or males, respectively.

% Number of cases is taken from incidence data of Table 7 and 1997 estimated USA population.

NA indicates data are not available from the indicated source. Areas in shaded background indicate no entries would be appropriate.

(1) National Institutes of Health (NIH) (1997): Disease-specific estimates of direct and indirect costs of illness and NIH support. National Institutes of Health, Office of the Director, Department of Health and Human Services (United States). April. Reference year for original cost data is 1991. Source for coronary heart disease prevalence: Phase I, National Health and Nutrition Examination Survey III (NHANES III), 1988–91, NCHS and the American Heart Association. Source for mental health prevalence, NIMH (1998).

(2) NIH (1997), as in (1) above except original cost data reference year is 1990. See text for data from National Cancer Institute (1998).

(3) Cost data: NIH (1997). Prevalence data: see text.

(4) Original cost data for 1985, population > 65 years of age (NIH, 1997).

(5) Original cost data for 1991 (Ernst and Hay, 1994). Number of cases calculated from total cost and cost per case.

(6) Based on midpoint of estimated prevalence in USA of 250,000 to 350,000 in 1990 (Anderson et al., 1992).

(7) Includes, low birthweight, pre-term delivery. Prevalence rate is per 1000 live births. See text for additional information. Source: Table 11, Health, United States, 1995, NCHS, USPHS, Hyattsville, MD.

## Table 9. Incidence, Mortality and Costs in California for Selected Cancer Types[a]

| | Incidence | | Deaths | | | Annual Cost | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Incidence[¢] | Mortality | | |
| | Number[@] (1997) | Rate[#] | Number (1997) | Rate[&] (1991) | PYLL[£] | Direct, per case[§] ($) | Indirect, per case ($) | Direct ($ Million) | Direct ($ Million) | Indirect[¶] ($ Million) | Total ($ Million) |
| ***Adult Cancers*** | | | | | | | | | | | |
| All cancers[%] | 140,230 | 603 | 54502 | 258.5 | 173403 | 38,900 | 85,000 | 5,455 | 2,120 | 8,017 | 10,137 |
| Breast Cancer, Female | 19,950 | 170 | 4438 | 39.4 | 23388 | 66,700 | 54,800 | 1,331 | 296 | 1,077 | 1,373 |
| Breast Cancer, Male[¥] | 157 | 1.4 | 29 | 0.31 | 50 | 38,900 | 85,000 | 6 | 1 | 3 | 4 |
| Prostate cancer | 25,594 | 223 | 3543 | 40.3 | 1470 | 37,000 | NA | 947 | 131 | 85 | 216 |
| Brain and CNS cancer [¥] | 1,846 | 7.9 | 1454 | 6.2 | 9235 | 38,900 | 85,000 | 72 | 57 | 396 | 452 |
| Lung cancer[(b)] | 21,275 | 91.5 | 15765 | 71.1 | 34933 | 45,200 | NA | 962 | 713 | 1,752 | 2,465 |
| Kidney cancer[¥] | | | 1000 | 4.9 | 3188 | 38,900 | 85,000 | | 39 | 153 | 192 |
| Melanoma[¥] | 3,658 | 11.1 | 774 | 3.6 | 6178 | 38,900 | 85,000 | 142 | 30 | 264 | 294 |
| Leukemia[¥] | 5,179 | 13.3 | 2366 | 9.3 | 2620 | 38,900 | 85,000 | 201 | 92 | 100 | 193 |
| Acute myelogenous leukemia[¥] | 891 | 3.8 | 711 | 2.9 | 3448 | 38,900 | 85,000 | 35 | 28 | 140 | 167 |
| Hodgkin's disease[¥] | 722 | 3.1 | 199 | 0.77 | 2315 | 38,900 | 85,000 | 28 | 8 | 89 | 97 |
| Non-Hodgkin's lymphoma[¥] | 5,179 | 22.3 | 2184 | 9.4 | 7053 | 38,900 | 85,000 | 201 | 85 | 314 | 399 |
| ***Childhood Cancers***[¥] | | | | | | | | | | | |
| All cancers | 1509 | 15.5 | 433 | 4.1 | 20369 | 38,900 | 85,000 | 59 | 17 | 1,598 | 1,614 |
| Leukemia | 416 | 4.3 | 162 | 1.6 | 4052 | 38,900 | 85,000 | 16 | 6 | 318 | 324 |
| Acute lymphocytic leukemia | 309 | 3.2 | 86 | 0.84 | 4052 | 38,900 | 85,000 | 12 | 3 | 318 | 321 |
| Acute granulocytic leukemia | 60 | 0.6 | 27 | 0.25 | 1277 | 38,900 | 85,000 | 2 | 1 | 100 | 101 |
| Hodgkin's lymphoma | 119 | 1.2 | 9 | 0.10 | 444 | 38,900 | 85,000 | 5 | 0 | 35 | 35 |
| Non-Hodgkin's lymphoma | 95 | 1.0 | 19 | 0.20 | 888 | 38,900 | 85,000 | 4 | 1 | 70 | 70 |
| Brain/CNS tumors | 254 | 2.6 | 71 | 0.65 | 3330 | 38,900 | 85,000 | 10 | 3 | 261 | 264 |
| Astrocytoma | 117 | 1.2 | 32 | 0.3 | 1383 | 38,900 | 85,000 | 5 | 1 | 37 | 38 |
| Neuroblastoma | 58 | 0.6 | 25 | 0.2 | 1258 | 38,900 | 85,000 | 2 | 1 | 31 | 32 |

Notes:

[@] Expected from age-specific incidence for California, 1989-1993, using the 1970 standard million to obtain adult and childhood age-adjusted rates, and using estimated 1997 midyear population of California to obtain estimated incident cases in 1997.

[#] Age-adjusted annual rate per 100,000 *adults* or 100,000 *children* for adult and childhood cancers, respectively, for both genders and all races, *except* gender-specific rates for breast and prostate cancer. Source: Incidence counts and rates, 1989-1993, California DHS, Cancer Surveillance Section. Age-adjusted to 1970 standard million U.S. population by the direct method.

[&] Annual age adjusted rate (AAR) per 100,000 population calculated using the 1970 standard million U.S. population by the direct method. AAR for ages >20y is shown for adults and AAR for 0-19y for children.

[£] Productive years of life lost (PYLL) before age 65.

[§] Direct costs assigned using data from NIH (1997). Costs for "all cancer" assigned where no other data are applicable. See Table 8 (Annual Costs of Selected Illnesses in the USA [1997]) for additional information and sources.

[¢] Cost based on number of incident cases. This cost cannot be added with the mortality-based costs because there would be double-counting of those cases that represent deaths in that year.

[¶] Lost earnings are calculated from the present value of future earnings (4% discount rate) given up due to death before age 65. These values are based on deaths in 1991, adjusted for 1997 California population, inflated to 1997 dollars, and are independent of the calculations of costs given by NIH (1997).

[%] Deaths due to malignant neoplasms, ICD-9 codes 140-208.

[¥] Direct costs assigned on basis of direct costs for all cancer.

[(a)] Incidence data are from rates for California (averaged for 1989-93), except for lung cancer where USA data were used. Both national and California incidence rates were applied to the 1997 California population. California mortality data (1991) adjusted to 1997 California population. Costs are from national data; see text & Table 8 (Annual Costs of Selected Illnesses in the USA [1997]) for sources.

[(b)] Lung cancer incidence rate is for adult population based on California data (1989-93) for cancer of the lung and bronchus. Adult mortality rate includes cancer of trachea, bronchus and lung (ICD-9 162). Note, the *total population* mortality rate for lung, trachea and bronchus is 44.2 per 100,000, based on California 1991 data. Sources: NCHS, 1996 (for incidence), California DHS, Cancer Surveillance Section (1991 data) (for mortality).

**Table 10.1. Impact of Non-Cancer Diseases in California: Estimated Incidence and Mortality from Adverse Reproductive Outcomes (1997)**

| | Incidence | | Mortality | |
|---|---|---|---|---|
| Condition | Number[@] | Rate[#] | Number | Rate[&] |
| Birth defects (1983-1990) | 16483 | 30.3 | 913 | 168 |
| Low birth weight | 32096 | 59.0 | 279 | 51 |
| Infant mortality [(a)] | | | 3779 | 695 |
| Neonatal mortality [(b)] | | | 2304 | 424 |
| Post-neonatal mortality [(c)] | | | 1475 | 271 |

Notes:

[@] Annual average of cases based on 544,000 live births in California in 1997 and incidence rates from 1992 (California Department of Health Services, Birth and Death Records).

[#] Incidence rate per 1,000 live births (1992).

[&] Mortality rate per 100,000 live births (1992).

[(a)] ICD-9 codes 001-999 for infant deaths (< 1 yr) California, 1992 Vital Statistics of California, 1992, table 4-4; mortality for ICD-9 765 shown per 100,000 live births.

[(b)] Neonatal period is age <= 27 days. Cost per perinatal case from NIH (1997).

[(c)] Postneonatal period is after 27 days to 1 year. Costs per perinatal case from NIH (1997).

**Table 10.2. Impact of Non-Cancer Diseases in California: Incidence, Mortality, and Potential Years of Life Lost (1992)**

| | Incidence | | Mortality | | |
|---|---|---|---|---|---|
| Disease or Condition | Number[¶] | Rate[§] | Deaths (1992) | Rate[£] | YPLL[+] |
| Amyotrophic lateral sclerosis | 494 | 1.5 | 372 | 1.22 | 1388 |
| Alzheimer's disease [(a)] | 60,879 | 185 | 1,185 | 3.20 | 125 |
| Coronary heart disease (ischemic) | [(b)] | [(b)] | 45,115 | 132.2 | 61672 |
| Cardiac arrhythmia | 10,151 | 30.8 | 875 | 2.50 | 2596 |
| Depression | 2,208,450 | 9.5% | | | |
| Bipolar disorder[(c)] | 232,468 | 1.0% | | | |
| Major depression[(c)] | 255,715 | 1.1% | | | |
| Dysthymia[(c)] | 1,563,689 | 6.7% | | | |
| Digestive disorders | 2,076,291 | 6.3% | | | |
| Headache | 560,269 | 1.7% | | | |
| Suicide | 2,379 | 6.2% | | | |

Notes:

[¶] Annual average derived from age-specific incidence rates, 1989-1993 and estimates of the midpoint population ofCalifornia, 1989-1993. Source: 1989-1993 California DHS, Cancer Surveillance Section.

[§] Annual average age-adjusted to the 1970 standard million U.S. population using the direct method unless otherwise noted. Rate per 100,000 persons of total population, except where percentages are shown.

[£] Rate per 100,000, age-adjusted to the 1970 standard million U.S. population using the direct method.

[+] Years of Potential Life Lost (before age 65).

[(a)] Annual incidence estimated from a community study of incidence (Hebert et al., 1995). See text for additional details.

[(b)] Incidence data not available; prevalence of heart disease is shown elsewhere.

[(c)] Percentage of USA adults (18 years and above) (ECA, Unpublished Year 2 data as quoted by National Institute of Mental Health, 1998).

**Table 10.3. Impact of Non-Cancer Diseases in California: Costs for Adverse Reproductive Outcomes (1997)**

| | Cases per year | | Direct Cost | | Indirect Cost | | Total Cost | |
|---|---|---|---|---|---|---|---|---|
| | Incident[@] | Deaths | Per Case[¶] ($1000s) | All Cases[¶] ($ Millions) | Per Case ($1000s) | All Cases ($ Millions) | Per Case ($1000s) | All Cases ($ Millions) |
| Birth defects (1983-1990) [(a)] | 18,205 | 913 | 91.1 | 1,660 | 270 | 4,000 | 360 | 5,660 |
| Low birth weight [(b)] | 35,449 | 279 | 10.3 | 365 | 4,050 | 1,130 | 4,060 | 1,500 |
| Infant mortality [(c)] | | 3,779 | 8.1 | 31 | 4,050 | 15,300 | 4,060 | 15,330 |
| Neonatal mortality [(d)] | | 2,304 | 8.1 | 19 | 4,040 | 9,300 | 4,050 | 9,320 |
| Post-neonatal mortality [(e)] | | 1,475 | 8.1 | 12 | 4,030 | 5,950 | 4,040 | 5,960 |

Notes:

[@] Estimated from incidence rates and 544,000 live births in California in 1997 (California Dep't of Finance, Demographic Research Unit, January 1998).

[§] Derived from age-specific mortality rates (1992); 4% discount rate applied.

[¶] Costs of treatment, except for birth defects where lifetime costs are given. The costs of birth defects are weighted averages for 18 birth defects reported by Waitzman et al. (1994, 1995) (cited by the California Department of Health Services in "California Morbidity", Monthly Report from Prevention Services, January, 1997).

[(a)] A weighted average cost (1988) was calculated from lifetime costs for 18 defects using number of cases (1988) as the weighting factor. Adjusted to 1997 dollars using the medical care price index. Source: CDHS *loc cit.*

[(b)] As listed in code ICD-9 765. Indirect (mortality) costs calculated from age-specific mortality rates (1992) and 1997 births. Indirect cost per case (decedent cases only) is based on premature loss of life before age 19 years discounted at 4% and adjusted to 1997 dollars.

[(c)] ICD-9 codes 001-999 for infant deaths (< 1 yr) California, 1992 Vital Statistics of Califonia, 1992, table 4-4. Indirect cost per decedent as described for low birth weight (above).

[(d)] Neonatal period is age <= 27 days. Cost per case based on perinatal costs from NIH (1997). Indirect cost per decedent as described for low birth weight (above).

[(e)] Postneonatal period is after 27 days to 1 year. Cost per case based on perinatal costs from NIH (1997). Indirect cost per decedent as described for low birth weight (above).

**Table 10.4. Impact of Non-Cancer Diseases in California: Total, Direct, and Indirect Costs for Selected Diseases (1997)**

| | Annual Rate | | | Cost per Case ($) | | | Cost ($ Billion) | | |
|---|---|---|---|---|---|---|---|---|---|
| Illness | Incidence[¶] | Prevalence[¶] | Cases[%] | Direct | Indirect | Total | Direct | Indirect | Total |
| Heart Disease [(1)] | | 8,332 | 1,764,748 | 53,200 | 37,600 | 90,900 | 94.0 | 66.4 | 160.3 |
| Coronary Heart Dis. [(1)] | | 5,194 | 1,100,000 | 43,700 | 37,800 | 81,500 | 48.1 | 41.6 | 89.7 |
| All Cancer [(2)] | 381 | | 1,018,688 | 38,900 | 85,000 | 123,900 | 39.6 | 86.5 | 126.2 |
| Breast Cancer (female) [(2)] | 105 | | 142,575 | 66,700 | 54,800 | 121,500 | 9.5 | 7.8 | 17.3 |
| Prostate Cancer (male) [(2)] | 138 | | 183,211 | 37,000 | NA | NA | 6.8 | NA | NA |
| Lung Cancer [(2)] | 61 | | 162,765 | 45,200 | NA | NA | 7.3 | NA | NA |
| Allergy [(3)] | | 1,981 | 5,301,197 | 330 | 143 | 470 | 1.7 | 0.8 | 2.5 |
| Depressive disorders [(1)] | | 9,500 | 15,795,059 | 1,816 | 837 | 2,653 | 28.7 | 13.2 | 41.9 |
| Alzheimer's Disease [(2,4)] | 185 | | 494,388 | 55,600 | 235,500 | 291,100 | 27.5 | 116.4 | 143.9 |
| Alzheimer's Disease [(5)] | NA | | 516,898 | 63,100 | 147,100 | 210,200 | 27.3 | 81.3 | 108.7 |
| Multiple Sclerosis [(2,6)] | | 112 | 300,000 | 12,000 | 10,500 | 22,500 | 3.6 | 3.1 | 6.8 |
| Perinatal conditions [(7)] | | 72 | 288,817 | 8,100 | | | 2.3 | | |

Notes:

USA resident population, July 1, 1997, 267,636,000 (estimated, U.S. Bureau of the Census).

* Costs are expressed in 1997 dollars by adjustments based on the hourly wage index (business sector) (applied to indirect costs) or Consumer Price Index for Medical Care (applied to direct costs). "Cases per Year", "Direct Cost per Case", and "Total Cost per Case" are based on 1997 USA population. Note however that the underlying data were collected at various times before 1997.

[¶] Rate per 100,000 persons per year except "Perinatal conditions" (see note #7 below). Breast cancer and prostate cancer rates apply to only females or males, respectively.

[%] Number of cases is taken from incidence data of Table 7 and 1997 estimated USA population.

NA indicates data are not available from the indicated source. Areas in shaded background indicate no entries would be appropriate.

[(1)] National Institutes of Health (NIH) (1997): Disease-specific estimates of direct and indirect costs of illness and NIH support. National Institutes of Health, Office of the Director, Department of Health and Human Services (United States). April. Reference year for original cost data is 1991. Source for coronary heart disease prevalence: Phase I, National Health and Nutrition Examination Survey III (NHANES III), 1988–91, NCHS and the American Heart Association. Source for mental health prevalence, NIMH (1998).

[(2)] NIH (1997), as in (1) above except original cost data reference year is 1990. See text for data from National Cancer Institute (1998).

[(3)] Cost data: NIH (1997). Prevalence data: see text.

[(4)] Original cost data for 1985, population > 65 years of age (NIH, 1997).

[(5)] Original cost data for 1991 (Ernst and Hay, 1994). Number of cases calculated from total cost and cost per case.

[(6)] Based on midpoint of estimated prevalence in USA of 250,000 to 350,000 in 1990 (Anderson et al., 1992).

[(7)] Includes, low birthweight, pre-term delivery. Prevalence rate is per 1000 live births. See text for additional information. Source: Table 11, Health, United States, 1995, NCHS, USPHS, Hyattsville, MD.

**Table 11. Annual Consumer Price Index for All Items and Medical Care 1982-1997; Wage Index 1985-1997**

| Year | All Items[a] | Medical Care[a] | Wages[b] |
|---|---|---|---|
| 1982 | 96.5 | 92.5 | |
| 1983 | 99.6 | 100.6 | |
| 1984 | 103.9 | 106.8 | |
| 1985 | 107.6 | 113.5 | 73.2 |
| 1986 | 109.6 | 122.0 | |
| 1987 | 113.6 | 130.1 | |
| 1988 | 118.3 | 138.6 | |
| 1989 | 124.0 | 149.3 | |
| 1990 | 130.7 | 162.8 | 90.7 |
| 1991 | 136.2 | 177.0 | *94.5* |
| 1992 | 140.3 | 190.1 | 100.0 |
| 1993 | 144.5 | 201.4 | 102.5 |
| 1994 | 148.2 | 211.0 | 104.5 |
| 1995 | 152.4 | 220.5 | 107.8 |
| 1996 | 156.9 | 228.2 | 111.8 |
| 1997 | 160.5 | 234.6 | *114.3* |

[a] Change in percent from 1982-84 base period =100. Source: US Bureau of Labor Statistics, Consumer Price Index–All Urban Consumers (CPI-U).

[b] Compensation per hour, business sector. Change in percent from 1992 base period = 100. Source: US Bureau of Labor Statistics, as shown in Statistical Abstract United States 1997, table 664. Data in *italics* are interpolated.

**Table 12. Pupil Enrollment and Staff Employed in California Public Schools (1996-1997), by Institutional Category**

| Grade or Specialization | Pupils | Teachers | Administration, Classified Staff, Pupil Services | Schools |
|---|---|---|---|---|
| Elementary | 3,932,378 | 151,384 | | 5,097 |
| Middle and junior high schools | 976,246 | 50,099 | | 1,106 |
| High school | 1,408,038 | | | 851 |
| Continuation | 61,960 | | | 520 |
| Special education, alternative, juvenile hall/community, K-12 school, community day | 126,136 | 26,781 | | 407 |
| Vocational | | 6,475 | | |
| Other | | 15,788 | | |
| **TOTAL** | **5,612,965** | **257,988** | **159,028*** | **7,981** |

*Excludes 122,918 part-time classified staff.

Source: Educational Demographics Unit, California Department of Education (http://www.cde.ca.gov)

**Table 13. Contents of Files on Disease Rates and Health Costs**

| Filename | Contents |
|---|---|
| Diseas~1.xls | Average annual age-specific incidence (1989-1993) and mortality rates (1991), estimated incident cases, and numbers of cases in California for:<br>Childhood cancer: all cancer, acute lymphocytic leukemia, chronic lymphocytic leukemia, acute granulocytic leukemia, leukemias, Hodgkin's disease, non-Hodgkin's lymphoma, brain/CNS tumors, astrocytoma, Wilm's tumor, neuroblastoma.<br>Adult cancer: all cancers, breast cancer (female), prostate cancer, lung cancer, leukemia, all lymphoma, acute myelogenous leukemia, brain tumor, Hodgkin's lymphoma, non-Hodgkin's lymphoma, melanoma, breast cancer (male).<br>Non-cancer illnesses: amyotrophic lateral sclerosis (ALS), Alzheimer's disease, cardiac arrhythmia, coronary heart disease, depression, manic-depressive illness, major depression, dysthymia (mood disorders), digestive disorders, headache, suicide. Reproductive failures: birth defects, low birth weight, infant mortality.<br>Numbers of deaths by age group for diseases with mortality data.<br>YPLL for diseases with mortality data.<br>Present value of future earnings (1994 data) at 4% discount rate applied to premature deaths.<br>Distribution of California population by age groups using California data (1989-'93). Standard age distribution using the standard million (1970) population. Distribution of California population by age and gender; ratios of males to females, percent males, percent females.<br>Weighted average costs for birth defects.<br>Note: Incidence and mortality data listed in 5-year intervals. Calculations were made for lifetime incidence and for ages 0-19 years (children) and >20 y (adults).<br>These data are incorporated into Tables 8-10. |
| LossCst2.xls | For adults and children, separately: Incidence numbers and rates; mortality numbers and rates, direct and indirect annual costs from cancer deaths calculated on the basis of average age-adjusted California incidence rates (1989-1993), 1991 mortality rates, California population (1996), and 1991 data for costs. Potential years of life lost (PYLL) calculated from age-specific mortality data. Adjustments of population and cost to 1997 were made (see worksheet "Factors"). Data from this file appear in Tables 9 and 10. |
| CostCas2.xls | Total, direct and indirect costs for selected diseases based on NIH and other research. Also, cost per case (direct and indirect), total cost per case. Incidence and prevalence rates are given, as appropriate. These data are the basis for cost of illness data incorporated into LossCst2.xls. The data appear as Table 8. Worksheets "Cal '85 to Cal '97" and "Cal vs USA Cost Proportions" contain subsidiary calculations performed to transform 1985 California health costs to 1997 (adjusting for population, wages, and prices) in order to compare these California and USA costs for 1997; these results appear in the text. |